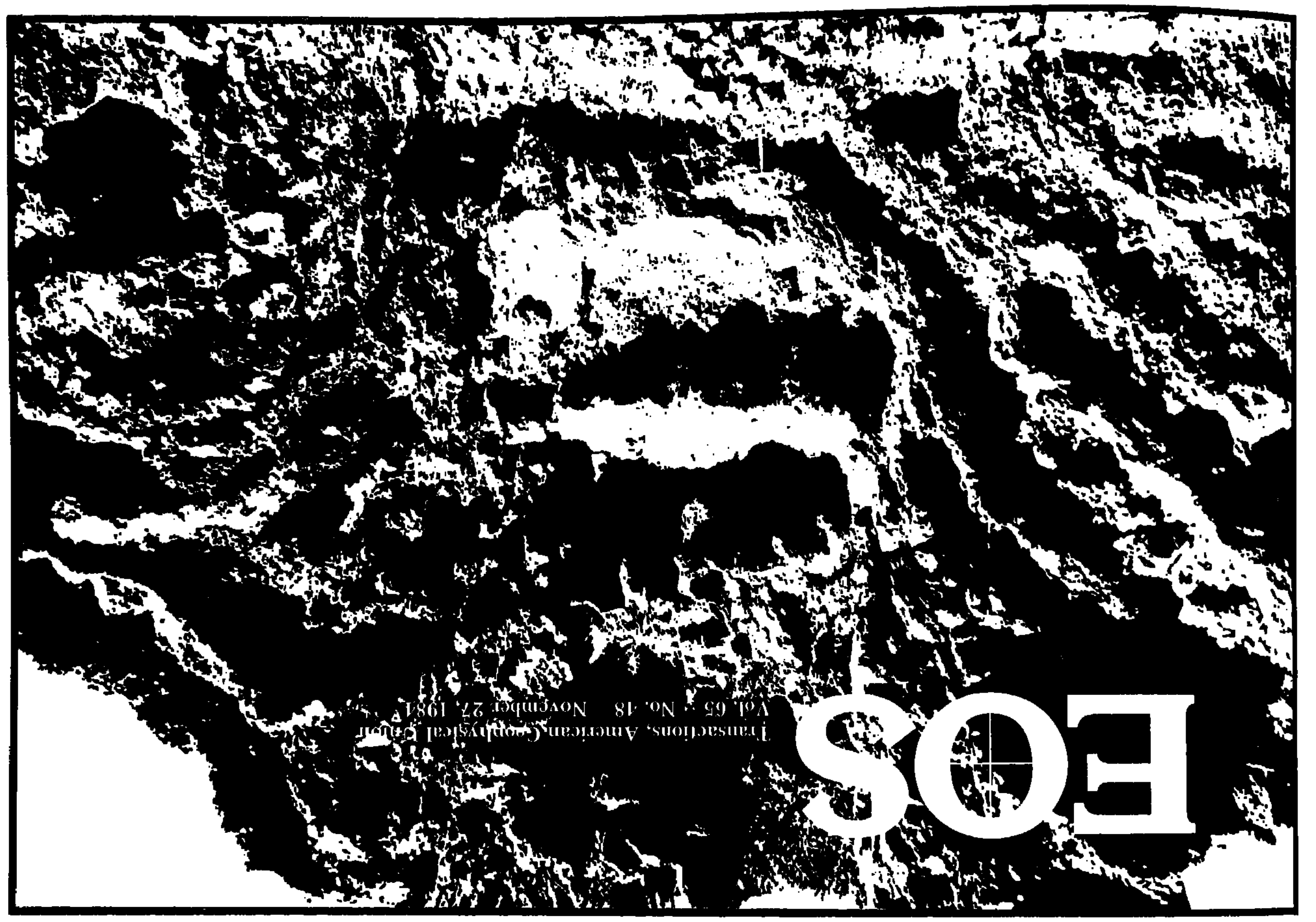

Eos, Transactions, American Geophysical Union Vol. 65, No. 48, Pages 1193 – 1200 November 27, 1984

Particles and Fields—Ionosphere

5505 Airglow
HIRIS ROCKETBORNE SPECTRA OF INFRARED FLUORESCENCE IN THE $O_3(v_3)$ BAND NEAR 100 km
W.T. Rawlins and G.E. Caledonia (Physical Sciences Inc., Research Park, P.O. Box 3100, Andover, Massachusetts 01810)
J.J. Gibson and A.T. Stair, Jr. (Infrared Technology Division, Air Force Geophysics Laboratory, Hanscom AFB, Massachusetts 01731)
High-resolution $O_3(v_3)$ spectral emission data, obtained between 80 and 125 km during an aurora by the rocketborne HIRIS cryogenic interferometer spectrometer, have been analyzed by a spectral simulation/least squares technique. Data obtained below 110 km exhibit behavior which is independent of local auroral strength, and thus appear to represent quiescent nightglow. The derived vibrational state population distributions for levels $v_3' \geq 1$ can be expressed as vibrational "temperatures" of 400-600 K. This result is interpreted in terms of formation of $O_3(v_3')$ by three-body recombination of O with O_2, as well as other radiative and collisional processes. Additional data, obtained near 120 km and sampling intense auroral arcs, indicate a hitherto unexpected auroral enhancement of $O_3(v_3)$ fluorescence intensity and vibrational state distribution.
J. Geophys. Res., A, Paper 4A1292

5535 Interactions between waves and particles
A THEORY OF DIFFUSE EMISSION BURSTS TRIGGERED BY COHERENT VLF SIGNALS PROPAGATING PARALLEL TO THE GEOMAGNETIC FIELD
J.P. Matthews (Space Science Department of ESA/ESTEC, Noordwijk, The Netherlands)
Satellite and ground based studies have demonstrated that coherent VLF signals propagating in the terrestrial magnetosphere can trigger diffuse and structured emission bursts. A triggering mechanism for diffuse emissions which may operate when the coherent signal propagates parallel to the geomagnetic field is investigated in this note. The theory is based on the concept that trapping of energetic particles in the potential wells of the coherent signal alters the gradient of the particle distribution function with respect to parallel velocity. If, as a result of trapping, the gradient becomes sufficiently steep, broad band wave growth takes place as predicted by established theory. The resulting pitch angle diffusion of particles produces a more stable configuration in which the steep gradient is reduced towards that corresponding to the marginally stable distribution. For initially positive gradients in the energetic electron distribution function with respect to parallel velocity, wave growth takes place above the frequency of the causative coherent signal. The theory predicts that the bandwidth of emissions triggered in this way should rapidly increase with time and may reach maximum widths of several hundred Hz.
J. Geophys. Res., A, Paper 4A1306

5535 Interactions Between Waves and Particles
RESULTS FROM THE SEEP ACTIVE SPACE PLASMA EXPERIMENT: EFFECTS ON THE IONOSPHERE
W. L. Imhof (Lockheed Palo Alto Research Laboratory, Palo Alto, CA 94304), H. D. Voss, J. B. Reagan, D. W. Datlowe, J. Mobilia, R. A. Helliwell, U. S. Inan, J. Katsufrakis, and R. G. Joiner
An active satellite-ground coordinated space plasma experiment was conducted from May to December 1982 in which electrons were precipitated from the radiation belts into the ionosphere by the controlled injection of VLF signals from ground-based transmitters. The results confirm the hypothesis that electrons can be precipitated from the radiation belts by ground-based VLF transmitters and they provide information relating to the effects of such precipitation on the ionosphere. The ionization versus height profiles produced in the atmosphere by the modulated signals from ground-based VLF transmitters are presented along with representative profiles associated with naturally occurring electron precipitation events. In comparison to the strongest transmitter event observed on 17 August 1982, the ionization produced by naturally occurring electron precipitation can be much larger or much smaller.
Rad. Sci., Paper 4S1333

5540 Ion densities and temperatures
IONOGRAM ANALYSIS: LEAST-SQUARES FITTING OF A CHAPMAN-LAYER PEAK
J. E. Titheridge (Physics Department, The University of Auckland, Auckland, New Zealand)
Electron-density profile calculations can use plasma frequency FN as a function of real height h near a layer peak. This allows data from lower heights, and scaled critical frequencies from both magneto-ionic components, to be combined in a single least-squares solution. The scaled critical frequencies do not define the final value, but provide additional input to the least-squares calculation. Results give directly the R.M.S. fitting errors for the critical frequency, the peak height and the scale height.
Calculations begin with an assumed model value for the scale height near the peak. With good data the final result is independent of this model. As the amount and consistency of the data decreases, the solution automatically gives more weight to the initial (model) scale height. This greatly reduces the normal tendency for peak extrapolations to become erratic or absurd as the quality of the data decreases. With very poor data the model scale heights are still obtained from a least-squares solution, with some physical constraints. Thus optimum results are obtained with good data, and acceptable peak profiles are obtained from all useful ionograms. (Ionogram, real height, profile).
Rad. Sci., Paper 4S1321

5545 Ionospheric disturbances
UHF/GHz SCINTILLATION OBSERVED AT ASCENSION ISLAND FROM 1980 THROUGH 1982
J.P. Mullen (Emmanuel College, Boston MA 02115), E. MacKenzie, Santimay Basu and H. Whitney
Three years scintillation measurements taken at Ascension Island have been reduced and are presented here. The 1.5 GHz and 257 MHz signals of MARISAT were supplemented by 3.9 GHz observations during January-May 1981. While their temporal patterns are similar to those found earlier in the Afro-American zone, they exhibited unusually frequent occurrence of heavy scintillation at GHz frequencies often exceeding 30 dB at 1.5 GHz and 7 dB at 4 GHz. These patterns are attributed in part to the position of the station near the southern peak of the Appleton anomaly. Comparisons are made between these and similar observations taken at Hong Kong, near the northern peak of the anomaly. (Equatorial scintillation, UHF/GHz scintillation, Appleton anomaly, magnetic index).
Rad. Sci., Paper 4S1358

5545 Ionospheric disturbances
BOTTOMSIDE SINUSOIDAL IRREGULARITIES IN THE EQUATORIAL F REGION: 2. CROSS-CORRELATION AND SPECTRAL ANALYSIS
B. L. Cragin (Space Sci. and Physics Prog., Univ. of Texas at Dallas, Richardson, TX 75083), C. E. Valladares, W. B. Hanson, and J. P. McClure
Equatorial bottomside sinusoidal (BSS) irregularities have been studied by applying techniques of cross-correlation and spectral analysis to the Atmosphere Explorer data set. In order to determine the spatial displacements between the density and transverse velocity components of the irregularities, we have cross-correlated the ion density data from the Retarding Potential Analyzer with the pitch and yaw ion velocity components as measured by the Ion Drift Meter. The analysis indicates that the pitch velocity component is displaced by somewhat more than 90° (referred to the wavelength of the spectral peak) to the west with respect to the ion density fluctuations. However, [illegible]
J. Geophys. Res., A, Paper 4A8275

5545 Ionospheric disturbances
SAINT-SANTIN RADAR OBSERVATIONS OF LOWER THERMOSPHERIC STORMS G. Mazaudier and R. Bernard (CNET/CRPE, 4 Avenue de Neptune, 94100 Saint-Maur, France), S. V. Venkateswaran
Incoherent scatter measurements of ion drift velocities obtained by Saint-Santin - Nançay radar have been used to study the lower thermospheric wind disturbances during geomagnetic storms. A storm-time meridional circulation with equatorward wind velocities at higher altitudes (135 km) is revealed. The transition altitude below which the circulation reverses direction is also traceable. The strength of the circulation is in good agreement with Blanc and Richmond's 1980 model simulation for intense storms. Some evidence is also found for phase variations in the semi-diurnal tide during storm periods, but its interpretation is difficult because of the restriction of the data to daytime hours. (Neutral winds, incoherent scatter measurements).
J. Geophys. Res., A, Paper 4A8705

5580 Wave propagation
THE DIFFRACTION OF VLF RADIO WAVES BY A PATCH OF IONOSPHERE ILLUMINATED BY A POWERFUL HF TRANSMITTER
R. Barr, M.T. Rietveld, P. Stubbe and H. Kopka (Max-Planck-Institut für Aeronomie, 3411 Katlenburg-Lindau, F.R.G.)
Measurements have been made at Skibotn in Northern Norway of the effect of powerful HF waves, from the heating facility at Ramfjordmoen, on the propagation of VLF waves from the Omega transmitter (12.1 kHz) near Aldra and the 16.4 kHz transmissions (JXN) at Helgeland. The HF beam was deflectable in a North-South direction which enabled it to intersect the VLF propagation path. The VLF amplitude and phase perturbations were found to oscillate about zero as the beam was scanned across the propagation path and typical daytime amplitude and phase perturbations had maximum magnitudes of ~ 0.1 dB and 0.5 degrees. The maximum values appeared when the heated beam was symmetrically located across the VLF path. A study of the temporal variability of the amplitude and phase perturbations at a fixed beam deflection angle (38°S) showed that large enhancements of up to two orders of magnitude occurred in the amplitude and phase perturbations at times when the total received VLF field strength passed through a minimum. Maximum amplitude and phase perturbations of 6 dB and 50 degrees were recorded during one such minimum in the total received signal. Theoretical computations are presented which evaluate the diffracting effect of a heated patch of auroral ionosphere on multimode propagation in the earth-ionosphere wave-guide. Computations of propagation under a series of ionospheres ranging from typical day-time to night-time have been made and the normal and enhanced amplitude and phase perturbations have been successfully modelled. Attempts at reproducing the perturbing effects of a mobile heated patch have not been nearly so successful, especially at large deflection angles. (VLF propagation, ionospheric perturbation, ionospheric heating, diffraction).
J. Geophys. Res., A, Paper 4A8295

News

U.S. Space Strategy

Following the formal announcement of a national space strategy in August, President Ronald Reagan is moving ahead on many of his administration's declared objectives for strengthening the U.S. role in space-based research and space exploration.

Possibly the most significant long-term aspect of the administration's national space strategy is its emphasis on international cooperation. While the U.S. space program in the 1960's and 1970's was fueled by intense competition in the race to be the first to put a man on the moon, it may very well be characterized through the beginning of the next century by the spirit of international collaboration. The national space strategy calls for "increased international cooperation in civil space activities," particularly in the "development and utilization" of the space station. In addition, in late October, President Reagan announced the possibility of a joint U.S.-Soviet simulated space rescue mission. In his statement, Reagan said that the U.S. "is prepared to work with the Soviets on cooperation in space in programs which are mutually beneficial and productive."

Furthermore, National Aeronautics and Space Administration (NASA) administrator James M. Beggs has suggested the possibility of a joint U.S.-Soviet lunar base. Many consider a manned lunar base the next logical goal after successful operation of the earth-orbiting space station. Speaking at a NASA symposium on "Lunar Bases and Space Activities in the 21st Century" at the end of October, Beggs noted that the establishment of a permanently manned lunar base would require the development of new technologies as well as management techniques and economic analyses to make it feasible and profitable. Because of the magnitude of such a project, Beggs said, international cooperation to share "risks and benefits" will be required. Such a project, he said, "might even prove an irresistable lure to the Soviets," which would "certainly enhance the prospects for peace." Beggs predicted that the United States would return to the moon within the next 25 years.

The administration's major goal for the civil space program, as outlined in the national space strategy, is to establish a "permanently manned presence in space." In this regard, design of the space station is moving ahead as scheduled. In September 1984, NASA issued a request for proposals (RFP) for definition and preliminary design of a permanently manned space station, which would be in low earth orbit by early in the 1990's. The RFP included four "work packages" of space station elements. NASA is planning to award competing contracts for each package that will be effective April 1, 1985.

Thirteen bids had been received by NASA by the submission deadline of November 15, 1984. Boeing, General Dynamics, and Martin Marietta all bid on the first work package, which consists of pressurized "common modules" for use as laboratories, living areas, and logistic transport. Lockheed, McDonnell Douglas, and Rockwell International bid on the contract for the structural framework of the station. General Electric and RCA bid on work package three: preliminary design of automated free-flying platforms and provisions to service, maintain, and repair the platforms and other free-flying spacecraft. Garrett, Rocketdyne, and TRW all bid on preliminary design of electrical power generation, conditioning, and storage systems. The awarded contracts will last 18 months, and by 1987, NASA plans to begin final design and development of the space station.

Another major goal for the civil space program is to begin long-term planning for U.S. space activities into the next century. In October, President Reagan announced the creation of a national space commission, responsible for setting the agenda for the civil space program for the next 20 years. This blue ribbon panel will be composed of 15 presidentially appointed members who will "identify long-range goals, opportunities, and policy options for civilian space activity." The commission will be funded through NASA and will complete its study late in 1985.

Hand in hand with the long-range commission report will be a study to review the goals and missions of civil agencies involved in earth science research "to insure a vigorous and balanced program of civil scientific research and exploration in space." The study, just getting underway, is to be completed by April 1, 1985, and is being coordinated by the White House Office of Science and Technology Policy (OSTP). OSTP will seek input from policy-level personnel at agencies such as NASA, the National Science Foundation, the National Oceanic and Atmospheric Administration, the Department of the Interior, and the Department of Agriculture. Chief among the objectives will be insuring that research areas are not being overlooked and that research efforts are not being duplicated. The report will be reviewed by the Senior Interagency Group (SIG) for Space, a panel of Cabinet-level members, before being sent to the President. Specifics on the scope and objectives of this study will be published in an upcoming issue of *Eos*.

To insure a healthy U.S. space transportation system (STS), otherwise known as the space shuttle, after October 1, 1988, shuttle pricing will reflect the full cost of operations carried out for commercial and foreign users. To complement space shuttle operations, the administration also is promoting private sector space operations. Congress recently passed the "Commercial Space Launch Law," which defines regulations that private companies must meet to launch expendable launch vehicles (ELV's) or commercial payloads into space. The Department of Transportation, through its new Office of Commercial Space Transportation, will serve as a central agency for processing commercial applications.

In addition, the administration is pushing for a change or elimination of tax laws that discriminate against commercial space ventures and will target and support basic research and development activities that "may have implications for investors aiming to develop commercial space products and services." Along these lines, NASA recently released its formal policy on commercial uses of space that contains a series of initiatives designed to reduce the technical, financial, and institutional risks of commercial ventures into space.—*DWR*

New Hydraulics Laboratory

The DeFrees Hydraulics Laboratory was opened in June 1984 as a 500-m² addition to the former hydraulics teaching laboratory in Cornell University's School of Civil and Environmental Engineering. Total laboratory space is now about 800 m² and is dedicated to basic and applied research and teaching in hydraulics, fluid mechanics, and hydrology. Three major equipment installations are in progress: a 33-m wave tank with a random wave generator for coastal/ocean engineering research, a 24-m wind-water tunnel for stratified flow and interfacial transfer research, and a 24-m tilting flume for open channel turbulence and sediment transport research.

Geophysicists

Wolfgang H. Berger, a professor of oceanography at Scripps Institution of Oceanography, has been awarded the 1984 A. G. Huntsman Award for Excellence in Marine Science from the Bedford Institute of Oceanography at Dartmouth, Nova Scotia, Canada.

Rear Admiral Charles K. Townsend, director, National Ocean Service Office of Marine Operations, has been awarded the Commerce Department's Gold Medal, its highest award. Townsend received the award for recognition of his work managing the Pacific Marine Center in Seattle, Wash., from 1980–1984.

Donald L. Turcotte, chairman of the Department of Geological Sciences at Cornell University, was awarded a Regents Medal of Excellence from Cornell.

Books

Eutrophication and Land Use: Lake Dillon, Colorado

William M. Lewis, Jr., James F. Saunders, III, David W. Crumpacker, Sr., and Charles M. Brendecke, *Ecol. Stud. Anal. Synth.*, vol. 46, Springer-Verlag, New York, x + 202 pp., 1984, $39.80.

Reviewed by Timothy K. Kratz

How and why a body of water responds to nutrient enrichment have been major questions facing aquatic ecologists for the past several decades. This book presents a 2-year case study of Lake Dillon, a mesotrophic reservoir in Colorado which is likely to receive higher nutrient input in the future. The authors claim three goals for the study: (1) to provide a comprehensive set of limnological data on the lake, (2) to detail present nutrient sources of the lake and how they relate to land use, and (3) to construct a model capable of predicting the trophic status of the lake given likely changes in land use. The authors are successful in accomplishing the first goal, do moderately in accomplishing the second, but leave the reader wondering about the third.

The book is organized logically and is easy to read. The first three chapters provide an introduction to Lake Dillon and detail the methods used in the study. Chapters 4 through 11 report basic limnological information and are probably the strongest chapters in the book. Because of the thoroughness of the data set, limnologists will find these chapters interesting and useful.

Chapters 12 through 15 deal with the nutrient contribution of the watershed. In these chapters, regression equations predicting nitrogen and phosphorous yield from various land use practices and point sources are developed. Yields from these sources are summed to give nutrient input to the lake. Deviations of the observed values from the predicted inputs based on these equations are assumed to be due to storage or removal of nutrients from river valleys. To deal with these discrepancies, the authors create an inventory function relating nutrient storage or removal to magnitude of water runoff in such a way as to minimize the difference between observed and predicted nutrient yield. One is hardly surprised when, after this correction, the various equations fit the observed data well.

Chapters 16 and 17 describe the model and the model's predictions. Rightly claiming that complex process models have limited use when prediction is a primary goal, the authors opt to design an empirical model. In an empirical model a variable of interest is predicted from one or more master variables. In this case the model first predicts mean annual total phosphorus concentration in the lake. From the total P estimate, chlorophyll *a*, secchi disk depth, and minimum O_2 concentration are predicted. Each of these parameters is an indicator of trophic status, so that with a given input of land use practices and water budget the model will make a prediction of the lake's trophic status. After running the model with 10 scenarios for land use practice and high or low water year, the authors conclude that the lake will become eutrophic if high growth occurs without the adoption of nonpoint source controls.

How good is the Lake Dillon model? The true test of an empirical model is how well it predicts. Predictive ability is difficult to assess from the information presented in the book. Unlike the preceding chapters, where discussion of sources of error is detailed, there is no discussion in chapters 16 and 17 of confidence limits for the model's predictions. One clue that the authors themselves may not be overly confident of the model's predictive ability is found in the final summary chapter. The chapter consists of 23 summary points which do an excellent job of presenting the major points of the book in condensed form. It may be significant that nowhere in the 23 points is any mention made of specific model predictions.

This book will be interesting and useful to lake managers in particular and to limnologists in general. Its major strength is the comprehensive presentation of limnological data. Lake modelers will likely find the modeling approach interesting but the model itself difficult to evaluate. At $39.80, most libraries and some scientists will be able to add this volume to their collections.

Timothy K. Kratz is the Site Manager of the Northern Lakes Long-Term Ecological Research Project of the Center for Limnology, University of Wisconsin, Madison.

1985 AGU Spring Meeting

Baltimore, Maryland
May 27–May 31

Call for Papers to be Published January 15, 1985

Abstract Submission: Abstracts should be submitted in standard AGU format. A sample abstract was published in *Eos*, August 14, 1984. The Call for Papers will contain detailed instructions and a sample abstract. **Abstract Deadline will be March 13.**

Scientific Sessions: Special Sessions will be listed in the Call for Papers. All scientific sessions will be held at the Baltimore Convention Center.

Program Committee:

Meeting Chairmen and Union (U) Frank Eden, National Science Foundation
Atmospheric Sciences (A) William Beasley, National Science Foundation
Geodesy (G) Demos Christodoulidis, Goddard Space Flight Center
Geomagnetism and Paleomagnetism (GP) William MacDonald, State University of New York, Binghamton
Hydrology (H) Leonard Konikow, U.S. Geological Survey, Reston
Ocean Sciences (O) Michael Bacon, Woods Hole Oceanographic Institution
Planetology (P) Raymond Arvidson, Washington University, St. Louis
Seismology (S) Charles Langston, Pennsylvania State University
SPR: Aeronomy (SA) G. G. Sivjee, University of Alaska, Fairbanks
SPR: Cosmic Rays and Solar and Interplanetary Physics (SC/SS) Leonard Burlaga, Goddard Space Flight Center (SC); Bruce Tsurutani, Jet Propulsion Laboratory
SPR: Magnetospheric Physics (SM) George Parks, University of Washington, Seattle
Volcanology, Geochemistry, and Petrology (V) Bruce Marsh, Johns Hopkins University, Baltimore

Social Events:

Icebreaker, May 27, 5:30–7:00 P.M.
Awards Ceremony, May 29, 5:30 P.M.
Awards Reception, May 29, (immediately following the reception)
President's Dinner, May 29, 8:00 P.M. (ticketed event)

Hotel Accommodations: Hotel reservations must be made through the Housing Bureau: deadline for reservations will be April 30. Detailed information on housing and meeting registration information will be published in late January. The meeting registration deadline will be May 9. The participating hotels and rates are:

Days Inn
100 Hopkins Place
($46 single, $54 double/twin)

Holiday Inn Downtown
301 West Lombard Street
($49 single, $59 double/twin)

Baltimore Plaza
Pratt and Eutaw Streets
($58 single, $68 double/twin)

Omni International
101 West Fayette Street
($68 single, $88 double/twin)

Tremont Plaza
222 St. Paul Street
($55 single, $65 double)

Howard House Hotel
8 North Howard Street
($42 single, $46 double, $50 twin)

The Oceanography Report

The Oceanography Report

The focal point for physical, chemical, geological, and biological oceanographers.

Editor: David A. Brooks, Department of Oceanography, Texas A&M University, College Station, TX 77843 (telephone: 409-845-5527).

A Multidisciplinary Oceanography Program on the Southeastern U.S. Continental Shelf

J. O. Blanton, J. A. Yoder, L. P. Atkinson, T. N. Lee, C. R. McClain, D. W. Menzel, G. A. Paffenhofer, L. J. Pietrafesa, L. R. Pomeroy, and H. L. Windom

Introduction

Since 1976, the U.S. Department of Energy has sponsored a multidisciplinary research program to determine the physical processes which drive circulation and control the chemistry and biology of the continental shelf waters off the southeastern United States (Figure 1). This area extends from Cape Hatteras, N. C., to Cape Canaveral, Fla. (often called the South Atlantic Bight (SAB)). Knowledge gained about water circulation across the shelf and at the western edge of the Gulf Stream has been used by cooperating investigators (Table 1) and others to describe the circulation of shelf water, to determine where and how certain trace elements are transported and transformed, and to relate the circulation regime to biological production. The following description of the program is presented under three headings: circulation, trace element geochemistry, and food chain dynamics.

Circulation

Two experiments were completed in 1980 and 1981, during which large arrays of current meters, temperature recorders, and bottom pressure recorders were deployed. The arrays, designed to document the response of shelf waters to events induced by wind and by Gulf Stream disturbances (Figure 2), showed that low-frequency current and temperature variability along the shelf break is primarily produced by eddylike disturbances along the Gulf Sream frontal zone. These disturbances travel northward at speeds of 0.5 to 0.7 m/s at periods of 5 to 10 days [*Lee and Brooks*, 1979; *Lee et al.*, 1981, 1984; *Lee and Atkinson*, 1983; *Kourafalou et al.*, 1984]. Along the middle shelf (depths of 20–40 m), currents at subtidal frequencies are strongly related to local wind forcing and pressure gradients [*Lee and Brooks*, 1979], similar to the response observed in the mid-Atlantic Bight [*Beardsley and Butman*, 1974; *Scott and Csanady*, 1976]. This portion of the shelf is vertically homogeneous in fall and winter. During spring and summer, the middle shelf is often vertically stratified, particularly in the northern and southern extremities of the SAB [*Atkinson et al.*, 1983].

Circulation on the inner shelf (depths of 0–20 m) is influenced primarily by local wind forcing. Currents are also modified by density effects from river runoff [*Blanton*, 1981]. Freshwater inputs produce a band of low-salinity water which establishes a frontal zone adjacent to the coast [*Blanton and Atkinson*, 1978] where some dissolved and suspended material is effectively trapped. We only have two "snapshots" (Figure 3) of the ocean currents on the inner shelf, where intensive measurements were made for a 2–3 day period [*Blanton*, 1981, 1984]. The along-front flow is related to the direction of along-front stress. Cross-front flow diminishes with decreasing distance above the bottom and veers cyclonically. We think that periods of northward wind stress effectively remove dissolved material from the inner shelf [*Blanton and Atkinson*, 1983]. On the other hand, sinking material may be trapped on the inner shelf by onshore flow near the bottom. Moreover, the lower layer circulation appears to be strongly convergent during southward flow, which would also inhibit the offshore transport of any suspended material near the bottom. Thus the ability of the coastal front to inhibit the transfer of material across the shelf depends, to some degree, upon the frontal structure and its response to wind stress.

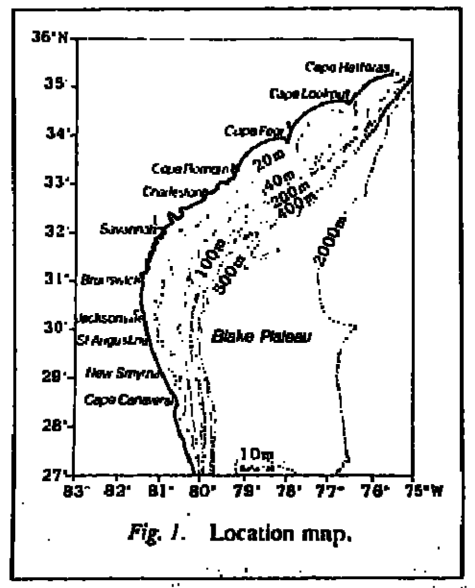

Fig. 1. Location map.

Trace Element Geochemistry

Shelf waters consist of Gulf Stream waters diluted to varying degrees by river runoff. Trace element concentrations, although largely determined by concentrations of the oceanic and freshwater end members, are also influenced by atmospheric inputs and by removal to, or release from, suspended and bottom sediments. We have examined some of the important pathways for mercury [*Windom and Taylor*, 1979], arsenic [*Waslenchuk*, 1978], copper [*Windom et al.*, 1983], nickel, cadmium, zinc, manganese, iron (H. L. Windom and R. G. Smith, Jr., unpublished manuscript, 1984) and lead (H. L. Windom, R. G. Smith, Jr., and M. Maeda, unpublished manuscript, 1984.)

Estuarine and inner shelf waters generally contain higher concentrations of trace metals than shelf waters near the Gulf Stream (H. L. Windom and R. G. Smith, Jr., unpublished manuscript, 1984). While inner shelf concentrations appear to result from the mixing of river and oceanic waters, atmospheric input is significant for some metals (Table 2).

The estuarine and inner shelf environment is a primary location for the deposition and resuspension of trace elements [*Bothner et al.*, 1980 (see also Figure 4)]. The concentration of cadmium is maximum between salinities of $30–33 \times 10^{-3}$, which suggests that cadmium is released from sediments on the inner shelf closest to the coast. On the other hand, iron concentrations suggest a first-order removal across the shelf (H. L. Windom and R. G. Smith, Jr., unpublished manuscript, 1984). Most of the removal probably occurs near the coast (i.e., salinities less than 30×10^{-3}).

Food Chain Dynamics

Since 1975, two types of upwelling events have been recognized as important to understanding biological productivity of the middle and outer shelf. Both types occur throughout the year at the shelf break in response to eddies and meanders of the Gulf Stream front which occur at characteristic periods of 5–10 days. These Gulf Stream disturbances affect the outer shelf (depths greater than 40 m) and cause nutrient-rich water to be present on the outer shelf approximately 50% of the time resulting in intense phytoplankton blooms [*Atkinson et al.*, 1978; *Lee et al.*, 1981; *Yoder et al.*, 1983]. This is the first type of upwelling. The second type begins as the first does but occurs when the Gulf Stream is vertically stratified, about May–October. Upwelled water then penetrates across the shelf as a subsurface intrusion of cold nutrient-rich water. The distance of penetration depends upon the wind stress, the local topography, and the density of resident shelf waters [*Atkinson*, 1977; *Blanton et al.*, 1981; *Janowitz and Pietrafesa*, 1982]. Intrusions are most dramatic south of Jacksonville, Fla., (30°N) and in the Carolina Cape region north of 33°N. Intrusions can penetrate all the way to the coast off northern Florida and north of Cape Fear but only to the middle shelf off Georgia and South Carolina. A given intruded water mass may result from several upwelling events at the shelf break and thus may have a residence time on the shelf of several weeks. Production in the intruded water mass reaches 3 g C m^{-2} d^{-1} near the peak of the phytoplankton bloom (J. A. Yoder et al., unpublished manuscript, 1984). The annual outer shelf estimate of primary production is 360 g C m^{-2} [*Yoder*, 1984].

Chlorophyll *a* concentrations in intruded water masses usually reach maxima about 1 week after intrusions occur (Figure 5). The doubling time of intrusion chlorophyll *a* is about 1–2 days, if exponential increases are assumed. This matches a half-life of 1–2 days for nitrate.

While production on the outer shelf is primarily controlled by upwelled nutrients, production on the inner shelf off Georgia and South Carolina is affected by recycling and by nutrients supplied from the many marshes and rivers [*Yoder*, 1984]. Annual inner shelf primary production averages 285 g C m^{-2} but exceeds 600 g C m^{-2} near the mouth of a major southeastern estuary [*Haines and Dunstan*; 1975; *Thomas*, 1966]. Four characteristics regulate primary productivity on the inner shelf. First, with the exception of the Florida coast south of 30°N and possibly the Carolina Capes area, phytoplankton production is not affected by upwelled nutrients. Instead, "new" nutrients enter the inner shelf from the many estuaries, salt marshes, and rivers that line the Georgia/South Carolina coast. A large proportion of the exported nitrogen is not available to phytoplankton until mineralized by heterotrophs because most is in dissolved organic and/or particulate organic form [*Bishop et al.*, 1984]. Second, light is attenuated quickly with depth due to the high turbidity of inner shelf waters [*Oertel and Dunstan*, 1981]. Third, the existence of the coastal frontal zone (discussed above) inhibits the cross-shelf exchange of dissolved and suspended materials [*Blanton*, 1981; *Yoder et al.*, 1981], thereby affecting the residence time of nutrients and phytoplankton on the inner shelf. Fourth, large tidal amplitudes (2–3 m) induce some sediment stirring in shallow water near the coast, which may release nutrients from the sediments [*Yoder*, 1984]. The importance of sediment-derived nutrients is being studied.

The shallowness of the inner shelf, the abundance of suspended matter, and tidal stirring enhance the abundance of bacteria [*Pomeroy et al.*, 1983]. Sediment/water interactions regenerate phosphate and ammonia and resuspend organic detritus. These processes provide additional substrates (compared to those available to mid- and outer shelf environments) for both free and attached bacteria and other microbes. Bacteria are more abundant and their mean size larger on the inner shelf than in the waters of the outer shelf. On the outer shelf the abundance of free bacteria is about 10^5/ml, reaching 10^6 above intrusions. On the other hand, normal abundance of free bacteria along the inner shelf is 10^6/ml [*Pomeroy et al.*, 1983].

High zooplankton densities are found within upwelled waters, particularly during summer, when intruded waters remain on the shelf for weeks. Dominant taxa include the appendicularian, *Oikopleura*, which reaches concentrations as high as ~ 10^3 specimens per m^{-3} within both intruded waters and the overlying surface mixed layer. Copepods of the genera *Paracalanus*, *Eucalanus*, and *Temora* and the cyclopoid *Oncaea* sp. attain densities of ~10^2 to 10^3 specimens per m^{-3}. These concentrations are similar to or surpass those of the same taxon in major upwelling areas of the world [*Paffenhofer*, 1983]. Growth and productivity of larval and adult fish may also be affected by upwelling events. Recent studies have shown that schools of adult fish were concentrated within intruded waters on the outer shelf [*Atkinson and Targett*, 1983]. In general, the outer shelf has more larval fish than the middle or inner shelf. Thus most larval fish are located in the shelf zone where the production dynamics of their probable food (plankton) is principally controlled by upwelling [*Yoder*, 1983].

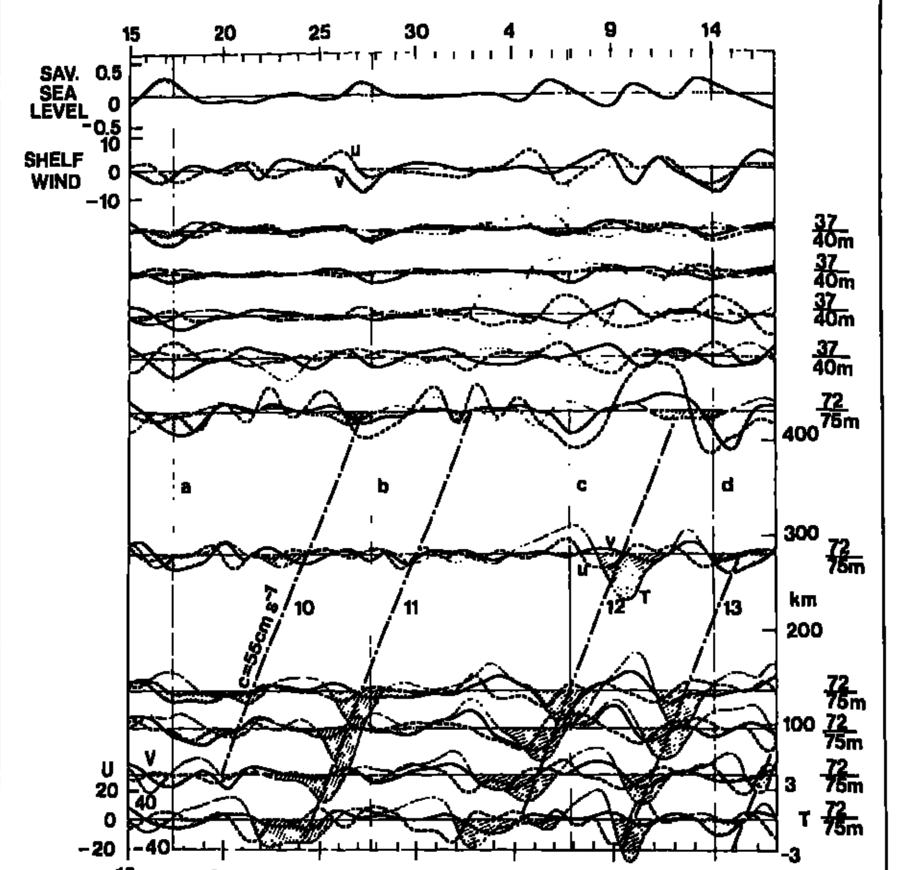

Fig. 2. Composite figure showing response of middle and outer shelf currents near bottom to Gulf Stream and wind events [from *Lee and Atkinson*, 1983]. Propagating events (10–13), shown by slanted lines, have a phase speed of 55 cm s^{-1} and connect cold anomalies at the shelf break (wavy hatching). Nonpropagating events (*a–d*), shown by vertical lines, connect southward wind and current events and coastal sea level set-up (dotted shading). Numbers at far right of figure denote depth of observation over total water depth.

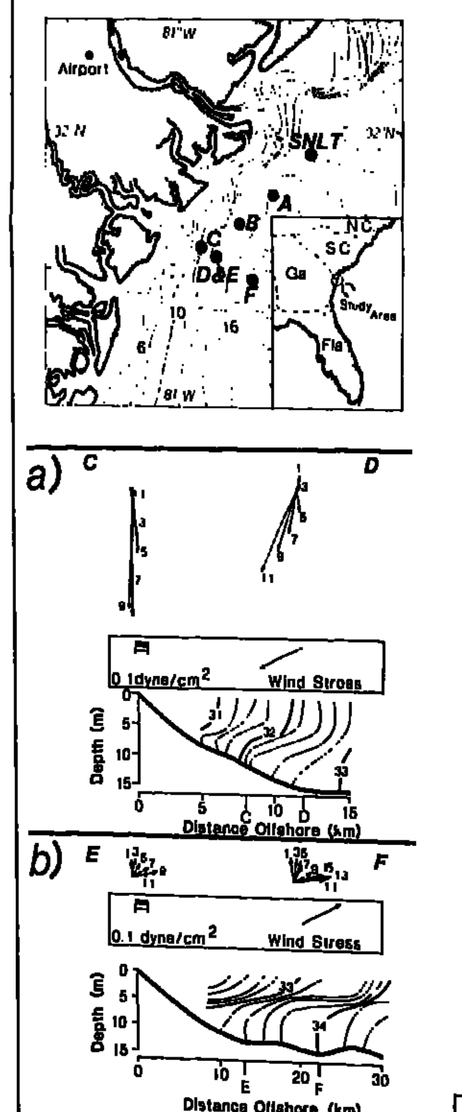

Fig. 3. Current hodographs at two locations in the inner shelf frontal zone during southward (*a*) and northward (*b*) wind stress. Note the more inclined frontal zone during southward stress and that flow near the surface is offshore during both conditions. Currents have been averaged for four consecutive tidal cycles.

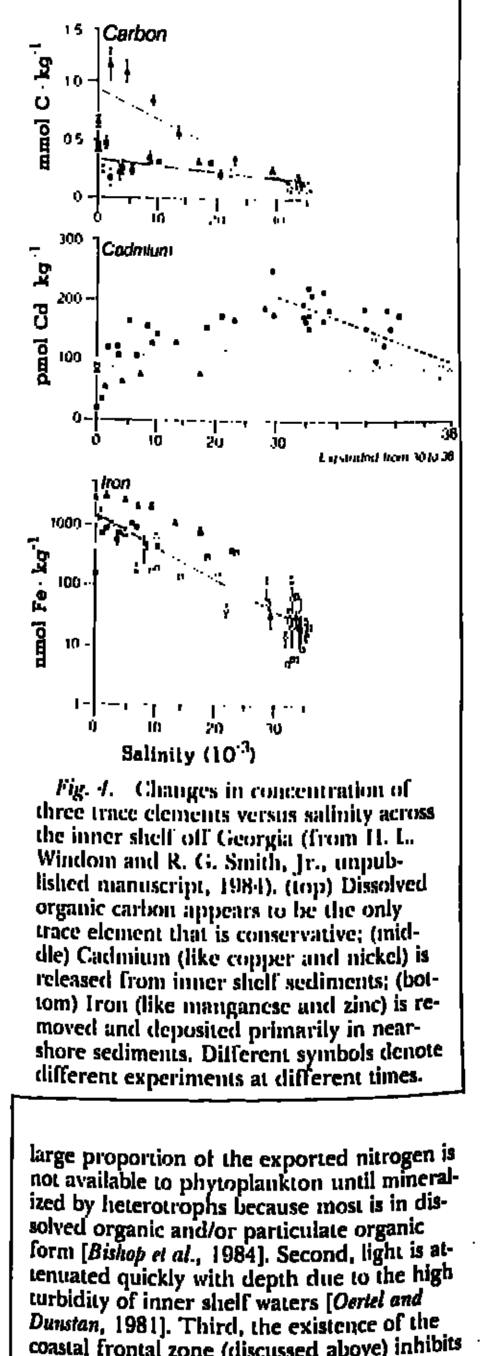

Fig. 4. Changes in concentration of three trace elements versus salinity across the inner shelf off Georgia (from H. L. Windom and R. G. Smith, Jr., unpublished manuscript, 1984). (top) Dissolved organic carbon appears to be the only trace element that is conservative; (middle) Cadmium (like copper and nickel) is released from inner shelf sediments; (bottom) Iron (like manganese and zinc) is removed and deposited primarily in nearshore sediments. Different symbols denote different experiments at different times.

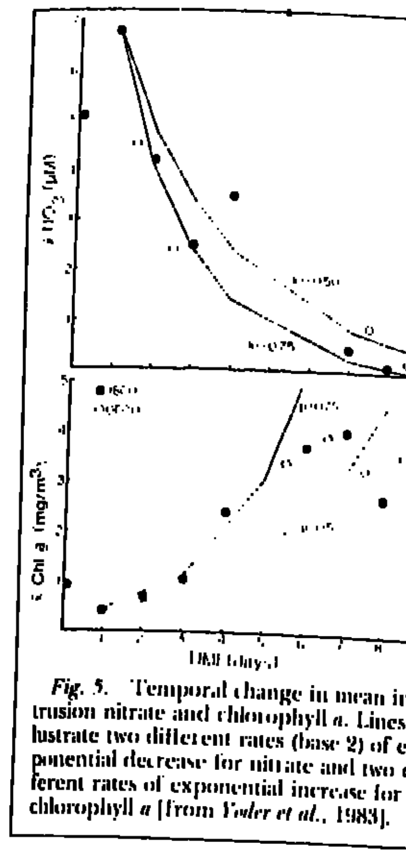

Fig. 5. Temporal change in mean intrusion nitrate and chlorophyll *a*. Lines illustrate two different rates (base 2) of exponential decrease for nitrate and two different rates of exponential increase for chlorophyll *a* [from *Yoder et al.*, 1983].

TABLE 1. Principal Investigation Supported by the Department of Energy in the Southeastern U.S. Continental Shelf Program

Investigator	Affiliation	Research Area
L. Atkinson	SKIO	hydrography, nutrient dynamics
J. Blanton	SKIO	inner shelf circulation, shallow water frontal zones
T. Lee	RSMAS	Gulf Stream dynamics, shelf circulation
C. R. McClain	NASA	remote sensing
D. W. Menzel	SKIO	program coordinator
G. A. Paffenhofer	SKIO	zooplankton, nutrient dynamics
L. J. Pietrafesa	NCSU	shelf dynamics, tidal currents
L. R. Pomeroy	UGA	microbiology, nutrient dynamics
H. L. Windom	SKIO	trace element dynamics
J. A. Yoder	SKIO	phytoplankton, nutrient dynamics

NASA: National Aeronautics and Space Administration/Goddard Space Flight Center; NCSU: North Carolina State University, Raleigh; RSMAS: Rosenstiel School of Marine and Atmospheric Science, University of Miami, Fla.; SKIO: Skidaway Institute of Oceanography, Savannah, Ga.; UGA: University of Georgia, Athens.

TABLE 2. Comparison of Atmospheric and Riverine Trace Metal Inputs to Shelf Waters

	Atmospheric Input,* nmol kg^{-1} yr^{-1}	River Input,* nmol kg^{-1} yr^{-1}	Ratio R (Atmospheric Input to River Input)	Resulting Zero Salinity End Member,† nmol kg^{-1}
Iron	6.3	23	0.27	700
Manganese	0.22	14	0.01	330
Cadmium	0.012	0.0026	4.6	0.39
Copper	0.95	0.37	2.6	32
Nickel	1.4	0.19	7.4	38
Zinc	1.9	0.40	4.8	57

*Assuming that shelf area is 5.9×10^4 km^2, that shelf water volume is 1600 km^3 [*Atkinson et al.*, 1983], and that total freshwater runoff is 66 km^3.

†Concentration = $(R + 1) C_r$, where R is the ratio of the atmospheric input to the river input and C_r is the observed weighted mean river water concentration.

Future Plans

There is increasing evidence that seasonal changes in the physical regime may eject materials to the outer shelf, where they may be entrained into the Gulf Stream. Climatological distributions of salinity [*Atkinson et al.*, 1983] suggests that low-salinity water is carried northward and offshore in spring and southward along the coast in autumn. This is consistent with climatological wind regimes [*Weber and Blanton*, 1980] and, in the spring situation, with evidence from satellite imagery (see cover, this issue). Whether the tonguelike distributions shown in the imagery are propagated or remain stationary is a question which requires further study. Other satellite images show a large pool of high chlorophyll *a* situated near the shelf break at 32°N.

An experiment in spring 1985 will test the hypothesis that material transported offshore from the inner shelf is entrained and removed from the region by a "semipermanent" cyclonic eddy at 32°N. This eddy results from the sudden turning of the Gulf Stream eastward at 32°N and its return to the shelf break at 33.5°N [*Pietrafesa, et al.*, 1978; *Bane and Brooks*, 1979]. While evidence suggests that low-salinity water appears near the shelf break at 32°N in spring, we do not know the trajectory, nor do we understand the biological and chemical processes that occur along the way. Our first experiment, SPREX (spring removal experiment), will take place during a time that will derive maximum benefit from a U.S. Mineral Management Service study of the Gulf Stream. During that time, current meters will be deployed over a 3–4 month period, and two ships will be used over a 20-day period to conduct Lagrangian flow experiments, obtain continuous horizontal profiles of temperature, salinity, and chlorophyll *a*, map hydrographic properties of shelf waters, and conduct biological sampling for phytoplankton, zooplankton, and bacteria. In addition, several special arrays will be deployed in areas off the Georgia coast as shallow as 4 m to measure currents and subsurface pressure. Investigators from the Brookhaven National Laboratory will also participate in these studies.

Low-salinity water is carried along the coast and southward during autumn [*Atkinson et al.*, 1983]. It is usually found hugging the coast of Florida during October. Presumably, this water is entrained and removed by energetic eddies influenced by bottom topography near Cape Canaveral [*Blanton et al.*, 1981; *Lee and Atkinson*, 1983]. An experiment is planned in the Cape Canaveral area within the next 2–3 years.

Acknowledgments

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The authors are with the Skidaway Institute of Oceanography, Savannah, Ga.

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Cover. Surface pigment concentrations off the southeastern coast of the United States are highest at the coast (red areas). Somewhat lower concentrations (yellow areas) extend offshore, particularly in the area east of Savannah, Georgia, where the Gulf Stream turns eastward (dark blue area bordering light blue areas). Note the isolated path of higher concentration (yellow) just upstream from the eastward deflection. This patch is the result of high primary production generated by upwelling in the cold core of a Gulf Stream frontal eddy or filament [see *McClain et al.*, 1984]. This image originated from the Coastal Zone Color Scanner aboard the Nimbus 7 Satellite, April 17, 1979. Color code for pigment concentrations (in milligrams per cubic meter): blue, <0.25; light blue, 0.25–0.45; light green, 0.45–0.7; dark green, 0.7–1; yellow, 1–2; red, 2–4; brown, >4. For further information, see article "A Multidisciplinary Oceanography Program on the Southeastern U.S. Continental Shelf," by Jackson O. Blanton, this issue, The Oceanography Report, p. 1202. (Photograph courtesy of C. R. McClain, National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.)

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University of South Carolina. Two year postdoctoral research assistant position anticipated. Person should have a strong background in structural geology of complexly deformed regions along with an interest in geologic mapping and integration of diverse kinds of geologic and geophysical data. Starting date as early as January 15, 1986. Closing date for applications December 31, 1984. Applications with vitae, interests and possible referees should be sent to: Prof. Robert D. Hatcher, Jr., Department of Geology, University of South Carolina, Columbia, SC 29208.

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Structural Geologist/Petrologist. The Department of Geology at George Mason University (state university in Northern Virginia: 15,000 students) seeks to fill a tenure track position at the assistant professor position to begin in Fall 1985. The successful applicant will teach undergraduate and graduate metamorphic petrology and structural geology. Preference will be given to applicants with additional expertise in economic geology, geophysics, or computer applications, who hold a PhD or have one year to completion, and who appear committed to an academic career involving teaching, research and service. The geology program is new, with new equipment in a new science building, four full-time faculty, several part-time faculty, 60 geology majors, and 10-20 geology B.S. graduates each year. The USGS-Reston and the Smithsonian-Washington are a short distance from the university. Applicants should send a statement of their teaching and research philosophy, a resume, and the names of three references by February 15 to Douglas Move, Department of Geology, George Mason University, Fairfax, VA 22030. AA/EOE.

Theoretical Astrophysics/University of Arizona. The University of Arizona is building an interdisciplinary program in theoretical astrophysics. Participating departments include Astronomy, Physics, and Planetary Sciences. We interpret theoretical astrophysics broadly, and areas of interest range from theoretical planetary physics to cosmology, including atomic and molecular physics, star formation, condensed matter physics, gravitational dynamics, et cetera.

We have just filled the first position under this initiative. We anticipate several more openings for tenure line faculty positions in theoretical Astrophysics over the next few years. Appointments will be in one or more of the participating departments and can be either senior or junior faculty level, depending on qualifications. Appointees will also be members of the Committee on Theoretical Astrophysics.

We invite inquiries and applications from qualified theorists for a position to be filled this year. Applicants should send their curriculum vitae and bibliography, together with the names of four professional references and any other supporting materials to Professor J.R. Jokipii, Chairmain of the Theoretical Astrophysics Steering Committee, Department of Planetary Sciences, University of Arizona, Tucson, AZ 85721 USA, before March 1, 1985. Later applications will be considered.

The University of Minnesota: Structual Geology/Tectonics. The University of Geology and Geophysics invites applications for a new, tenure track position in structural geology and tectonics. Candidates will be expected to carry out an active research program in their field of specialization, to assume teaching and advising responsibilities at the undergraduate and graduate levels. A Ph.D. is required. The position will be available fall 1985. Application deadline is February 15, 1985. Applicants should send curriculum vitae, list of publications, statement of research interests, and names of at least three referees to Peter Hudleston, Chairman, Department of Geology and Geophysics, University of Minnesota, Minneapolis, Minnesota 55455.

The University of Minnesota is an equal opportunity education and employer and specifically invites and encourages applications from women and minorities.

Faculty Position in Dynamical Oceanography.

An academic position (tenure track) is presently available at the assistant or junior associate professor level in the Department of Oceanography, Naval Postgraduate School. An ocean dynamicist experienced in the modeling of mesoscale ocean processes is preferred. The candidate should be competent in the analysis of pertinent observations, and be able to teach a variety of graduate courses in physical oceanography. The applicant should have an earned Ph.D. with an academic background in physical oceanography or a closely related field. Desirable attributes include field experimental interest and experience at sea and/or a strong interest in satelite remote sensing of the ocean. The successful candidate will be expected to teach one or two quarters per years, conduct sponsored research, and provide thesis supervision. The access to computer, data archive, and research vessel facilities is excellent. Basic ad applied research opportunities are abundant. Interactions with ocean dynamicists in the Meteorology Department are also possible. Salaries are attractive and are determined by the qualifications of the successful candidate. By 1 January 1985, send a curriculum vitae, the names oand addresses of three references, and a statement of research and instructional interes to:

Professor Christopher N.K. Mooers, Chairman
Department of Oceanography
Naval Postgraduate School
Monterey, CA 93943.

Applicants who are currently doctoral candidate will be considered for appointment as instructors, with a tenure track appointment upon completion of the degree. For additional information, telephone Professor Edward B. Thornton at 408-646-2847.

The Naval Postgraduate School is an equal opportunity/affirmative action employer.

Anticipated Seismology/Paleomagnetism/Tectonophysics Louisiana State University. The Department of Geology is searching for candidates to fill as many as four positions in geophysics and two in tectonophysics. The principal interest is in persons specializing in theoretical and applied seismology. Expertise in wave propagation, tomography, and/or digital processing is especially sought. Outstanding candidates in paleomagnetism are also sought, with emphasis on tectonic applications. In tectonophysics, specialization in rock mechanics or numerical modeling is of interest.

At the present the Department has three geophysicists and by Spring, 1985, will have two structural geologists. The geophysics program has a VAX 11/750 computer, a ProSeis seismic data processing system, several seismic field acquisition systems, and numerous terminals and peripherals for the VAX and the University's IBM 3081 and 3033 systems. Plans for acquiring additional computer equipment are underway.

Successful applicans are expected to offer graduate and undergraduate courses in their specialties and to develop a strong record of funded research and publication. The positions are at the Assistant Professor level, but appointment at higher rank will be considered for candidates with appropriate experience.

Applicants should submit a vita, representative reprints, and a statement of teaching and research interests and arrange for three letters of recommendation to be sent to: Chairman, SPT Search Committee, Department of Geology, LSU, Baton Rouge, LA 70803-4101.

LSU IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER.

Isotope Geochemist or Economic Geologist/University of Washington. The Department of Geological Sciences invites applications for a tenure track appointment at the Assisant Professor level with specialization in Isotope Geochemistry or Economic Geology. The position will be available in the Fall of 1985. Candidates must hold a Ph.D. degree and be committed to establishing a nationally prominent research program. Applicans in isotope geochemistry should have experience in the measurement of isotopic abundances in radiogenic systems, and in the application of isotopic data in solving problems in petrology, crust and mantle evolution or cosmochemistry. Applicants in economic geology should have a strong background in geochemistry with particular research interess in the application of chemical principles to the processes of ore genesis. Candidates will be expected to teach at both the undergraduate and graduate levels and to supervise graduate research.

Send letter of application, (including description of research interests), curriculum vitae, and names of four referees to Chairman, Search Committee, Department of Geological Sciences, AJ-20, University of Washington, Seattle, Washington 98195.

The University of Washington is an Affirmative Action/Equal Opportunity Employer.

Memorial University of Newfoundland Department of Earth Sciences, Centre for Earth Resources Research: NSERC/Petro-Canada Research Chair In Marine Crustal Seismology. Applications are invited for this new Research Chair in seismology at Associate or Full Professor rank. Funding for the Chair also provides for a senior research associate and a multichannel marine seismic system. Opportunities for collaborative research exist within the Centre, with industry and with the Atlantic Geoscience Centre particularly with projects on East Coast crustal structure. The Department has 35 faculty, 10 research fellows, 60 graduate students, well-equipped laboratories and a strong geophysics research group. In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. Send enquiries or application with names of three referees to: Dr. C.R. Barnes, Head, CERR, Department of Earth Sciences, Memorial University, St. John's, Newfoundland A1B 3X5, Canada. (Telephone 709-737-8142.)

Faculty Positions/The Pennsylvania State University. The Department of Geosciences invites applications for three (3) tenure track faculty positions in any of several fields of specialization. The faculty rank associated with each position is presently open, although salary funds currently available are sufficient for, at most, one senior full professorship. The successful candidates must be, or have demonstrated the potential to become, nationally recognized leaders in their fields. They must also have an interest in teaching and advising graduate and undergraduate students. Instructional and research areas in which particular needs have been identified include, but are not necessarily limited to: aqueous geochemistry, with emphasis on the kinetics of low-temperature rock-water interactions; experimental petrology, with emphasis on the equilibrium and kinetic properties of petrological systems; heavy isotope geochemistry, with emphasis on element distribution systematics and their geological applications; hydrogeology, with emphasis on the physics of fluid flow and mass transport through porous media; mineral physics/mineralogy, with emphasis on petrological applications of crystallochemical methods; rock physics, with emphasis on the dynamical properties of upper-crustal rocks; sedimentary geochemistry, with emphasis on diagenesis of fine-grained sediments and organic matter; and structural geology, with emphasis on regional tectonics.

The selection of persons to fill these three positions will be based in part on the extent to which their future research efforts will complement and further strengthen our programs in Geochemistry and Mineralogy, Geology, and Geophysics. Qualified persons should, therefore, include a brief description of their future research objectives with their resumes and the names of three references to:

C. Wayne Burnham, Head
Department of Geosciences
The Pennsylvania State University
5016 Deike Building
University Park, Pennsylvania 16802.

The deadline for applications is April 30, 1985.

An Equal Opportunity/Affirmative Action Employer.

Seismologist/University of Utah. The Department of Geology and Geophysics at the University of Utah seeks applicants for a tenure track faculty position in seismology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic imaging, seismic reflection or theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses and to pursue an active research program with graduate students. A seismic imaging laboratory with a VAX 11/750, PPS array processor, plotters, and processing and synthetic seismogram software is available to the successful candidate. Current research in seismology includes: earthquake research utilizing a PDP 11-70 computer, monitoring of the Intermountain seismic belt by an 85 station telemetered network utilizing an on-line PDP 11-34 computer; major experiments in seismic refraction and reflection profiling for crustal structure; and allied research in tectonophysics. The opportunity exists to participate with several other faculty in an integrated program of tectonics, seismology and sedimentology directed toward crustal studies and petroleum exploration. The geophysics component of the department has active research and teaching programs in electrical and electromagnetic methods, thermal properties of the earth, potential fields, and seismology. The department has close associations with the numerical analysis and data processing groups in computer science, electrical engineering and mathematics. The closing date for applications is December 31, 1984, and the appointment date is September 15, 1985. A Ph.D. is required for this position. Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals and names of two persons for reference. Qualified persons should send their applications to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112-1183.

The University of Utah is an equal opportunity/affirmative action employer.

Chairperson/The University of Tulsa, Department of Geosciences. Nominations and applications are invited for the position of Chairperson. Candidates should have a Ph.D. and a distinguished record of teaching and research. Leadership and administrative skills and experience to interact effectively with academics, industry and alumni are required.

The department of geosciences has ten faculty members and is located in a new teaching and research complex. There is a strong emphasis on soft rock geology and exploration geophysics in the department which has grown steadily in the last decade. Equipment includes a VAX 11-750 computer with an array processor and seismic data processing software, SEM, Microprobe, XRF, XRD, gas chromatographs and a mass spectrometer. Library resources which are supported by "Petroleum Abstracts" are excellent.

Nominations and applications should be sent to: Colin Barker, Department of Geosciences, University of Tulsa, 600 South College, Tulsa, Oklahoma 74104 by January 15, 1985.

The University of Tulsa is an equal opportunity/affirmative action employer.

University of Washington/Geophysics. Applications invited for a research faculty opening at the Assistant Professor level. Candidates are expected to establish innovative, high quality research programs in rock and mineral physics and to obtain funding (including salary) to maintain programs which should complement and/or augment existing programs in rock and mineral physics at the UW of Drs. J.M. Brown and Y. Sato-Sorensen.

Send resume and four letters of reference prior to January 15, 1985 to: Professor R.T. Merrill, Geophysics Program AK-50, University of Washington, Seattle, WA 98105.

The University of Washington is an affirmative action/equal opportunity employer.

Seismologist/University of Puerto Rico. The University of Puerto Rico and the Center for Energy and Environmental Research seek applicaiuns for a position in the field of seismology. The position is for part-time instruction at the University of Puerto Rico, Cayey and investigation of data from a 90-station short period, digital seismic network in Puerto Rico and the Virgin Islands. The applicant is expected to have demonstrated ability to work with data from a seismic network or ability to work on seismic hazard problems.

All interested persons should submit a letter of application, a detailed resume of educational experience and a summary of interests to:

Dr. William R. McCann
Lamont-Doherty Geological Observatory
Palisades, New York 10964
Telephone: 914-359-2900 ext. 377

University of California/Graduate Assistantships. University of California, Santa Barbara Graduate Fellowships, Teaching Assistantships and Research Assistantships in geology, geophysics, marine geophysics, Special Regents' Fellowships with four year of full support available to outstanding applicants. The department stresses a close interplay between geology and geophysics as well as field research opportunities both on land and at sea. Majors in physics, engineering and mathematics as well as geological sciences welcome. Apply to:

Professor Ken G. Macdonald
Graduate Advisor
Department of Geological Sciences
University of California
Santa Barbara, CA 93106.

Faculty Position. The Department of Earth and Space Sciences, SUNY Stony Brook invites applications for a tenure track faculty appointment. Rank and salary will be dependent on qualifications. Areas of specialization are open but preference will be given to applicants whose research interests complement those of the sedimentary geology program in the areas of: 1) quantitative modelling of heat and mass transfer on a regional or global scale; or 2) low-temperature geochemistry, sedimentary petrology, economic geology, hydrogeology. The successful candidate must have a Ph.D., a demonstrated research potential and an interest in teaching graduate and undergraduate students. Qualified persons should send a resume and arrange for three references to be sent to: Dr. G.N. Hanson, Chairman, Department of Earth and Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794–2100.

SUNY Stony Brook is an affirmative action/equal opportunity educator and employer. AK#300–84.

Northern Arizona University/Department Chairperson. Chairperson, associate or full professor, Department of Geology, Northern Arizona University, beginning summer 1985. Specialty open but preference will be given to applicants with a strong background in tectonics and tectonic problems. Applicants must be capable of interacting professionally with an active and diverse faculty of 14 geologists and geophysicists. Candidates should expect to continue an active research program, should have administrative capabilities and a dedication to quality teaching. The Department has been granted planning authority for a Ph.D. program so it is essential the successful candidate possess the desire to guide the Department through the final planning stages. NAU has a traditional emphasis on field problems in the Colorado Plateau and adjacent areas; we are expanding our analytical facilities to improve theoretical and experimental capabilities. Salary will be competitive and negotiable. Additional duties include teaching and supervising graduate student research. Application deadline: January 15, 1985. Send curriculum vitae, statement of research interests and names of four professional references to Search Committee—Code C, Department of Geology, Box 6030, Northern Arizona University, Flagstaff, AZ 86011.

Northern Arizona University is an equal opportunity/affirmative action employer.

Graduate Fellowships/University of Oklahoma. The School of Geology and Geophysics offers fellowhips for Ph.D. study in each of the following broad disciplines: (1) origin, ascent, and fractionation trends in magmas and associated ore deposits; (2) formation and tectonic evolution of continental lithosphere, including geophysical properties and structures of the upper crust; and (3) sedimentary processes, including organic and inorganic diagenesis, evolution of hydrocarbons, and correlation using biostratigraphic methods. Average fellowship stipends are for $10,000/9 month and are renewable annually on a competitive basis. Fellowship awards include a waiver of out-of-state tuition and fees.

The School of Geology and Geophysics presently consists of 19 full-time faculty. Research facilities in the school include a stable isotope laboratory; organic geochemistry laboratory; computer automated X-ray diffraction and fluorescence equipment; atomic absorption and neutron activation analysis equipment; scanning electron microscope with energy dispersive analyzer; transmission electron microscope; fission-track dating laboratory; fluid inclusion microthermometry laboratory; 2 kb hydrothermal laboratory for phase equilibrium experiments; high-pressure rock mechanics laboratory; paleomagnetic laboratory with a cryogenic magnetometer and thermal and AF demagnetization apparatus; 24-, 48-, and 192-channel digital seismic recording systems; a VAX 11–785 computer with high-resolution graphics and image-display terminals, with seismic and image processing software; and a 84,000 volume geology and geophysics library located in the department.

For further information on faculty and active research projects, contact: Kevin Crowley, School of Geology and Geophysics, University of Oklahoma, 830 Van Vleet Oval, Norman, OK 73019.

Seismologist/University of Illinois. Applications are solicited for a tenure-track position at the Assistant Professor level in seismology. A creative individual is sought who will develop a research program that complements our existing programs in seismology (currently emphasizing source properties), geodynamics, tectonics, and rock/mineral physics. An excellent research environment and outstanding facilities are available both in the Department and the University. A Center for Super Computer Research and Development is presently being formed at the University. In addition, our campus is the site of a proposed regional computational facility. Opportunity exists to interact with the department of Theoretical and Applied Mechanics. The position is expected to be filled as early as Fall, 1985. Salary is commensurate with experience; a PhD is required. The successful candidate is expected to participate in teaching and advising at the graduate and undergraduate levels. For equal consideration, interested individuals should send curriculum vitae, list of publications, statements of research interests and names of three or more references by December 15, 1984 to:

Professor Albert T. Hsui
Department of Geology
University of Illinois at Urbana-Champaign
1301 W. Green Street
Urbana, Illinois 61801.
Tel: 217/333-7732 or 333-3542.

The University of Illinois is an equal opportunity/affirmative action employer.

Chief, Land Sciences Branch: U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), GS-1801–14, Salary Range $42,928 to $55,807, Suitland, MD. The Climate and Earth Sciences Laboratory, National Environmental Satellite, Data, and Information Service (NESDIS), NOAA, announces a vacancy for the position of Chief, Land Science Branch. The Climate and Earth Sciences Laboratory is responsible for applying satellite observations to problems in the atmospheric, oceanic and land sciences. The Land Sciences Branch uses imagery and radiometric observations from meteorological and land resource satellites for studies in climatology, hydrology, glaciology, and agriculture. It is anticipated that the Land Sciences Branch will participate in the recently initiated International Satellite Land Surface Climatology Project. Branch scientists: 1) develop algorithms for deriving land surface variables from satellite radiance observations, 2) test, validate and apply these algorithms, and 3) perform research on land surface processes using the satellite based measurements. Examples of land variables of interest include snow and ice, skin temperature, surface radiation budget, soil moisture, vegetation cover, and hydrological parameters.

The successful applicant will direct the activities of the Branch and manage its resources, including research grants/contracts with external institutions. He will also actively engage in personal research in one of the land science areas. The successful applicant must have a record of scientific achievement on the application of remote sensing to the above stated problems, as evidenced by publications in the scientific literature. The position requires a Ph.D. in the physical sciences or equivalent and at least five years of relevant experience. Familiarity with programming of mainframe computers and experience with interactive image processing systems are also desirable.

Persons interested in applying must request a copy of the vacancy announcement, which contains qualification requirements, by writing to NOAA, FB4, Room 2051, Washington, D.C. 20233, ATTN: RAS/DC24, Barbara Jones, or calling 301-763-1986. Applications should be prepared on Standard Form 171.

Department of Commerce is an Equal Opportunity Employer. U.S. Citizenship required.

Faculty Positions/Arizona State University, Department of Geology. Applications are invited for two tenure track positions, beginning in August of 1985 at the rank of Assistant or Associate Professor. The selected candidates will be expected to display excellence in teaching and to develop vigorous programs of research on important geological problems. Research areas which complement our existing strengths, especially igneous, metamorphic, or sedimentary petrology, are the most desirable. Preference will be given to applicants with a demonstrably strong quantitative approach to problems of wide interest. Please send a detailed statement of research and teaching interests and a resume with names of four references by January 15, 1985, to Paul Knauth, Chairman, Department of Geology, Arizona State University, Tempe, AZ 85287.

Arizona State University is an equal opportunity/affirmative action employer.

Assistant Professorship in Obeservational Coastal Dynamics/University of North Carolina Institute of Marine Sciences, Morehead City. Tenure track position for a physical scientist with interests in neashore (continental shelf and/or estuarine) cirualtion will be availabel on July 1, 1985. This will be a research positon, carrying a nine-month state supported salary commentusrate with experience. The appointee will be expected to develop and carry out a field program in nearshore circulation. This person will be staffed at a research laboratory swhere programs related to coastal dynamics are underway. These programs include suidies of sediment dynamics, sediment/water chemical exchanges, plankton patchiness and larval dynamics. The appintee will also interact with faculty and students in an academic Curriculum in Marne Sciences at Chappel Hill. Faculty in this unit conduct research on carbonate platform geology, Gulf Stream dynamics and sediment/water chemical exchanges.

Interested applicants should send a letter describing their research intersts, a curriculum vitae and names of forur references to Dirk Frankenber, Director Institute of Marine Sciences, 3407 Arendell Street, Morehead City, NC 28557 by January 4, 1985.

The University of North Carolina is an affirmative action/equal opportunity employer.

Department of Geosciences/University of Houston. The Department of Geosciences has permission to hire at least one geophysicist to complement the 16 members of our faculty (3 in geophysics). This is a tenure track position with a starting date of August 1985. We are particularly interested in talking with individuals with a strong background in: theoretical seismology, experimental seismology, applied seismology. Salary and rank will be a function of experience. Applicants should submit: (1) a curriculum vita; (2) a brief statement of research interests; (3) a brief statement of teaching interests; (4) three letters of recommendation; (5) copy of graduate transcripts.

John C. Butler, Geosciences
University of Houston, University Park
Houston, Texas 77004

Stuart A. Hall will be at the AGU meetings in December and would like to talk with interested applicants.

The University of Houston is an equal opportunity/affirmative action employer.

Marine Geophysicist/Texas A&M University. The Department of Oceanography invites applicants for a tenure track position in its geological/geophysical section in the general field of marine geophysics and global tectonics. A Ph.D. is required. Rank and salary of the position are open. The successful applicant will be expected to initiate a vigorous research program, have an interest in seagoing activities, and interact with colleagues in the Departments of Oceanography, Geophysics, and the Geodynamics Research Program. Duties will also include the teaching of M.S. and Ph.D. students. The position is available beginning September 1, 1985. Applicants should submit a detailed resume including names of references and statement of research interests to T. K. Treadwell, Faculty Search Committee Chairman, Department of Oceanography, Texas A&M University, College Station, Texas 77843. Closing date for applications is January 31, 1985.

Texas A&M University is an equal opportunity/affirmative action employer.

Faculty Position in Structural Geology/Tectonics. The Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, has a tenure track opening at the Assistant or Associate Professor level in the area of structural geology/tectonics. The position will be filled for the beginning of the Fall 1985 term. The department currently has 31 full-time faculty, including 12 geologists and geophysicists.

The successful applicant will be expected to have completed the PhD degree. Courses to be taught include undergraduate structural geology as well as courses in structural analysis, tectonics, or other areas of research activity. He or she additionally will be expected to develop a vigorous program of sponsored research and to direct graduate student research projects at the MS and PhD level.

Please send complete resume and the names of at least three references to V.V. Cavaroc, Search Committee Chairman, Department of MEAS, North Carolina State University, Raleigh, NC 27695–8208; phone (919) 737-2212. Applications will be considered as received, with a closing date of January 15, 1985.

North Carolina State University is an equal opportunity/affirmative action employer.

Physical Oceanographer/North Carolina State University. Applications are invited for a nine-month, state funded, tenure track position at the assistant or associate professor level in descriptive physical oceanography. The successful applicant will have a Ph.D., a background inocean circulation and state of the art instrumentation, and will be expected to develop a strong field program and teach graduate level courses. He or she will also have the opportunity of interacting with thirty-two departmental facuty in various areas in oceanography, meteorology and geology. Send curriculum vitae and the names of three references by January 31, 1985 to: Dr. G.S. Janowitz, Chairman, Search Committee in Physical Oceanography, Department of Marine, Earth and Atmospheric Sciences, Box 8208, Raleigh, NC 27695–8208, Telephone 919-737-3711.

North Carolina State University is an equal opportunity/affirmative action employer.

Sedimentary Petrologist/Wright State University. The Department of Geological Sciences invites applications for a tenure track position in sedimentary petrology, at the assistant professor level beginning September 1, 1985. Candidates must have an interest in carbonate rocks and basin analysis. Preference will be given to people capable of teaching introductory paleontology. The Department has a large M.S. program and wishes to expand its sedimentary petrology group. Applicants should expect to complete all requirements for the Ph.D. in geological sciences or related field by September 1, 1985. Send resume and three letters of reference to Chairman, Search Committee, Department of Geological Sciences, 260 Brehm Laboratory, Wright State University, Dayton, Ohio 45435. Closing date for applications is January 15, 1985.

Wright State University is an equal opportunity/affirmative action employer.

Opportunities for Graduate Studies in Atmospheric Sciences at the Georgia Institute of Technology. Openings are available for outstanding individuals seeking an M.S. or Ph.D. degree in graduate studies in atmospheric sciences. For successful applicants, these positions include ½-time research assistantships with starting salaries ranging from $8,000 to $12,500/12 months, depending on the degree being sought and the student's qualifications. All tuition and fees are also covered by the Institute. Complete applications with supporting documentation should be received no later than March 15, 1984.

Interested students should write to:

Dr. Douglas D. Davis
School of Geophysical Sciences
Georgia Institute of Technology
Atlanta, GA 30332.

Seismologist/Ohio State University. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure track position for a seismologist with research interests in crustal geology and tectonics. The successful applicant must be prepared to assist in teaching exploration geophysics courses, advanced topics in his/her speciality, conduct research, and supervise graduate students. Postdoctoral or industrial experience is desirable. Rank and salary commensurate with experience and research record. Please send applications or nominations to:

Dr. Ralph R.B. von Frese
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Telephone: 614-422-5635 or 422-7221.

Applications should include a resume, a statement of research interests and the names and addresses of at least three persons whom we may contact for recommendations. The closing date for applications is December 1, 1984; or until position is filled; appointments can be effective as soon as October 1, 1985. Additional information can be obtained by writing or calling the chairman of the search committee.

The Ohio State University is an equal opportunity/affirmative action employer.

Texas Tech University/Geophysicist or Clastic Sedimentologist. The Department of Geosciences at Texas Tech University seeks applications for a tenure track position in the fields of geophysics or clastic sedimentology to begin August 1985. Rank and salary will be commensurate with qualifications. The Ph.D. is required. Entry-level applicants will be given preference. The primary responsibility would be to teach both graduate and undergraduate courses in geophysics or depositional systems and sedimentology, his/her specialty, and introductory geology. The person will be expected to initiate a research program and to direct MS and Ph.D. graduate students. Send a letter of application with complete curriculum vitae and names of three references to Dr. Alonzo D. Jacka, Chairman of Geosciences, P.O. Box 4109, TTU, Lubbock, TX 79409.

Texas Tech is an equal opportunity/affirmative action employer. Applications deadline: January 31 1985.

Geochemistry. The University of California, Davis will fill a permanent, tenure track, faculty position at the assistant professor level beginning Fall, 1985. Candidates having interests in isotope geochemistry and/or the geochemistry of economic deposits are especially encouraged to apply but other specialties in geochemistry will be considered. A PhD degree is required. Responsibilities include teaching at the undergraduate and graduate levels, and research in geochemistry.

Applicants should submit complete vita, a statement of research and teaching interests and the names of three referees. Deadline for application is January 15, 1985. Inquiries and applications should be directed to: Dr Howard W. Day, Department of Geology, University of California, Davis, CA 95616.

The University of California is an equal opportunity/affirmative action employer.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

Summer Course in Bio-Optical Oceanography. Focus is on interaction of light and phytoplankton. Light is a key factor in regulating phytoplankton productivity. In turn, plankton abundance and composition regulate light penetration in oceanic waters. Topics include radiative transfer theory, absorption and scattering, ocean color remote sensing, measurement of optical properties of seawater, phytoplankton pigments, photosynthesis, and physiological bases of optical variability.

Offered 22 July—24 August, 1985 at the Friday Harbor Laboratories, University of Washington, P.O. Box 459, San Juan Island, WA 98250. Enrollment limited to 12 students. Contact instructors for information on course content:

Dr. Mary Jane Perry
School of Oceanography, WB-10
University of Washington
Seattle, WA 98195
206-543-2652

or

Dr. Kendall Carder
Department of Marine Science
University of South Florida
St. Petersburg, FL 33701
813-893-9130.

For information on registration, contact the Friday Harbor Laboratories. Apply before 1 March 1985.

Availability of Request for Cooperative Agreement Applications: RFA# 1000-A. Acid Deposition Monitoring Support for Effects Research/U.S. Environmental Protection Agency. Application Receipt Date: January 18, 1985.

The U.S. Environmental Protection Agency (E.P.A.), under the National Acid Precipitation Assessment Program (NAPAP), is announcing the availability of funds for fiscal year 1985 for awarding a cooperative agreement(s) to support acid deposition monitoring stations to enhance the results of acid deposition effects studies. The research areas of primary interest involve studies of acid deposition (including ambient air pollution) mechanisms and rates of damage to forest ecosystems, calibrated watersheds and building materials. EPA has approximately one million dollars available to award cooperative agreement(s) to support this project. Support for this program may be for a period extending up to five years. In order to receive a copy of the RFA and further information contact:

Dr. Clarice E. Gaylord
Research Grants Staff
Office of Research & Development
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460
Telephone 202-382-7473.

STUDENT OPPORTUNITIES

Graduate Teaching and Research Assistantship in Marine Environmental Sciences and Coastal Oceanography. Opportunities for graduate study with graduate and research assistantships available for students interested in MS and PhD degree programs in marine environmental sciences and coastal oceanography. Awards cover tuition and academic year stipend up to $7,883. Additional summer support also available up to $3,000. Write: Graduate Programs Chairman, Marine Sciences Research Center, SUNY Stony Brook, Stony Brook, NY 11794.

Graduate Research Assistantships in Geophysics. Individuals with a background in mathematics, physics, engineering, or analytical geology are invited to apply for research assistantships in geophysics for the MS or PhD programs. Applicants should send a copy of their transcript, a statement of their research interests, and expected date of BS degree. Write to: R. Street, Department of Geology, Bowman Hall, University of Kentucky, Lexington, KY 40506.

GAP

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Exploration Geophysics

0920 Magnetic and electrical methods
FIRST RESULTS OF THE MOSES EXPERIMENT: SEA SEDIMENT CONDUCTIVITY AND THICKNESS DETERMINATION, BUTE INLET, BRITISH COLUMBIA, BY MAGNETOMETRIC OFFSHORE ELECTRICAL SOUNDING
R. N. Edwards (Geophysics Laboratory, Department of Physics, University of Toronto, Toronto, Ont., Canada M5S 1A7) L. K. Law, P. A. Wolfgram, D. C. Nobes, M. N. Bone, D. F. Trigg, and J. M. DeLaurier

A static electrical method has been developed to determine the electrical resistivity of crustal rock beneath the sea. The transmitter is a vertical, long-wire bipole, extending from the sea surface to the sea floor. A commutated current, generated on the ship, is fed to two large electrodes: one near the sea surface, the other at the end of a long insulated wire. The return path for the current is through the sea and the subjacent crust. The receiver is a self-contained, remote, microprocessor-controlled magnetometer which is deployed from the ship to the sea floor and subsequently recovered. The data are measurements of the azimuthal component of the magnetic field as a function of transmitter–receiver horizontal separation.

The acronym MOSES has been coined for the method. The choice of the name MOSES is appropriate because the system geometry is carefully arranged to remove many of the adverse effects of the relatively conductive sea water. In particular, accurate estimates of sea floor resistivity are possible because the data are proportional to the transmitted current from the source into the crustal material.

A sea test of the method in a water depth of 640 m was conducted in the "V" shaped Bute Inlet, British Columbia. Transmitted power was 1.25 kW; averaging time at each transmitter location was 1 hour. Transmitter-receiver separations ranged from 130 to 2 000 m. The resistivity and thickness of a sedimentary section beneath the sea were determined as 1.9 Ω·m and 560 m, respectively. The interpretation was accomplished both by matching the data converted to apparent resistivity to corresponding model type curves and by generalized linear inverse theory. Errors in the final parameters were estimated at about 9.2 percent using a parameter eigenvector analysis. The interpreted resistivity is in accord with direct measurement on core samples of sediment porosity. The interpreted thickness is less than an upper limit determined by extrapolating local inlet topography beneath the sea.
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TEST OF PIEZOELECTRIC AND PULSED RADIO METHODS FOR QUARTZ VEIN AND BASE METAL SULFIDES PROSPECTING AT GIANT YELLOWKNIFE MINE, N.W.T., AND SULLIVAN MINE, KIMBERLEY, CANADA
G.A. Sobolev (Earthquake Source and Rock Properties Department, Institute of Physics of the Earth, Moscow, B. Gruzinskaja 10.123242, U.S.S.R.) V. N. Demin, B.B. Narod, and P. Whaite

In the summer of 1983, G.A. Sobolev and V. N. Demin of the U.S.S.R. came to Canada to demonstrate techniques using piezoelectrical and other mechanoelectrical effects for in-mine geophysical surveys. We performed field trials using Soviet and Canadian equipment in the Giant Yellowknife Mine, N.W.T., and the Sullivan Mine, Kimberley, B.C., Canada.

Ore grade gold zones at the Giant Yellowknife Mine occur within large quartz lenses in a shear zone in Archean volcanics. Our tests there produced strong signals in the 8 kHz range, which were very similar to piezoelectrical signals produced by quartz samples, in the laboratory at the University of British Columbia.

The Sullivan orebody is a 160 million tonne iron-lead-zinc sulfide deposit lying conformably in Proterozoic rock. Our tests there yielded some very strong electromagnetic signals with frequencies as high as 350 kHz. The short delay times of these signals preclude any possibility that the signals were simple seismic phenomena generated at the antenna sites. Sobolev et al. (1982a, b) suggest that such high-frequency signals are produced by a highly nonlinear discharge phenomenon occurring at the grain boundaries of naturally occurring semiconductors such as galena, sphalerite, and pyrrhotite.
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0930 Seismic methods
LINEAR INVERSION OF BODY WAVE DATA—PART III: MODEL PARAMETERIZATION
K. Lee (Chevron Geosciences Company, P.O. Box 42832, Houston, TX 77242-2832) R.S. Jacobson

A velocity gradient model parameterized with the tau-zeta inversion for seismic refraction data is examined with respect to a synthetic traveltime data set. The velocity-depth model consists of a stack of laterally homogeneous layers, each with a constant velocity gradient. The free model parameters are the velocities of the layer bounds and the number of layers.

The best velocity gradient solutions, i.e., with the least deviation from the true model, were obtained from "constrained" models in which the velocities of the layer bounds are the velocities of the observed refracted waves. An arbitrary selection of layer bound velocities was found to be a suboptimal choice of model parameterization for the tau-zeta inversion.

A trade-off curve between model resolution and solution variance was constructed with constrained model parameterization from examination of numerous solutions with a diverse number of layers. A constrained model with as many layers as observed data points represents a satisfactory compromise between model resolution and solution variance. Constrained models with more layers than observed data points, however, can increase the resolution of the velocity gradient model. If model resolution is favored over solution variance, a constrained model with many more layers than observed data points is therefore the best model parameterization with the tau-zeta inversion technique.
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0930 Seismic methods
VELOCITY DETERMINATION IN LAYERED SYSTEMS WITH ARBITRARILY CURVED INTERFACES BY MEANS OF WAVE FIELD EXTRAPOLATION OF CMP DATA
C. P. C. Wapenaar (Delft University of Technology, Lab. Applied Physics, Group of Acoustics, P.O. Box 5046, 2600 GA Delft, The Netherlands) A. J. Berkhout

The paper starts with a brief review of conventional velocity determination procedures for plane-layered systems. These methods assume hyperbolic moveout curves in common midpoint (CMP) data. It is shown that in layered systems with arbitrarily curved interfaces these methods fail since the moveout curves are nonhyperbolic. The subject of this paper is a wave-theoretical approach to velocity determination. By means of wave field extrapolation of CMP data, nonhyperbolic moveout curves are transformed into hyperbolic ones. The proposed process is called velocity replacement (VR) since an inhomogeneous overburden is replaced by a homogeneous velocity medium. The effect of VR is illustrated on synthetic data. From the results it may be concluded that velocity determination after VR yields significantly more accurate results than velocity determination before VR. The technique of VR is also proposed as a preprocessing tool prior to stack in situations of nonhyperbolic moveout curves.
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INVERSION WITH A GRAIN OF SALT
Larry R. Lines (Amoco Production Company, P.O. Box 591, Tulsa, OK 74102) Sven Treitel

Although least-squares inversion is a useful tool in data analysis, nonuniqueness is an inevitable problem. This problem can be analyzed by considering the sensitivity of a model response to the parameter estimates. Such sensitivity methods produce extremal solutions which barely satisfy some resolution (or stability) criteria. Two closely related methods for producing such solutions are the "edgehog" and "most squares" methods due to Jackson (1973, 1976).

These techniques, which evaluate the "degree of nonuniqueness" in a least-squares inversion, require only the information computed in a singular value decomposition (SVD) solution. While the "edgehog" and "most squares" techniques are mathematically similar, the "most squares" estimate is the simpler to compute. Both methods show that the credibility of an inversion depends on both the specified error criterion as well as on the properties of the Jacobian matrix associated with the least-squares solution. The similar performance of these two closely related methods is demonstrated with the traveltime inversion of both synthetic and real vertical seismic profiles (VSPs). The sensitivity analysis of this inversion problem provides a quantitative measure of solution reliability.
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SYNTHETIC VERTICAL SEISMIC PROFILES FOR NONNORMAL INCIDENCE PLANE WAVES
F. Aminzadeh (Department of Electrical Engineering, SAL 300, University of Southern California, 1 University Park, Los Angeles, California 90089-0781) J. M. Mendel

Vertical seismic profiles (VSPs) are, by definition, recordings of seismic signals (total upgoing and downgoing seismic wave fields) at different depth points, usually at equally spaced intervals z_i = [illegible], i = 1, 2,..., I. In a nonnormal incidence (NNI) elastic model, where each layer is described by thickness, density, and P- and S- wave velocities, the mapping between time and depth needed to generate synthetic VSPs is not usually straightforward. In this paper we develop a relatively simple procedure for generating synthetic vertical and horizontal direction plane wave NNI VSPs. No spatial discretization is necessary. We (1) compute two surface seismograms, one vertical and the other horizontal, exactly as described in Aminzadeh and Mendel (1982); and (2) downward continue the surface seismograms to fixed VSP depth points. This paper demonstrates an algorithm for downward continuation of an elastic wave field using state-space representation and gives simulations which illustrate both X- and Z-direction primaries and complete VSPs for different geologic models and different incident angles.
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NUMERICAL MODELING OF REFRACTION ARRIVALS IN COMPLEX AREAS
N. R. Hill (Department of Geology, Rice University, P.O. Box 1892, Houston, TX 77251, Formerly Gulf Research and Development Company) P. G. Wuenschel

Use of refracted arrivals to delineate near-surface complex structure can sometimes be difficult because of rapid lateral changes in the refraction event along the line of control. The interpreter must correlate over zones of interference and zones of weak signal. During correlation it is often difficult to stay on the correct cycle of the waveform. We present a method to numerically model refracted arrivals in an area where these problems occur. The computation combines plane-wave field decomposition to calculate propagation in complex regions with a WKBJ method to calculate propagation in simple regions. To illustrate the method, we study a case where the near-surface complex structure is caused by the presence of low-velocity gaseous mud. The modeling produces synthetic seismograms showing the interference patterns and changes in intensity that are seen in real data. This modeling shows how correlations may be done over difficult areas, particularly where cycle skips can occur.
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